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13. Abstract ***(Maximum 200 Words)*** (abstract should contain no proprietary or confidential information)

Prostate cancer constitutes a major health problem. Although the medical techniques currently in use to diagnose prostate cancer are successful, the methods to stage the cancer and visualize the invasion and spread of the cancer are inadequate. MRI is known to be the best method for staging but it does not offer image resolution that is acceptable, especially for detecting disease in the anterior prostate. In the first year of the project, we have developed a phased array coil setup that enabled us imaging of the prostate with 160 microns image resolution. The second year, we have developed a mechanical setup that enabled placement of the needles in the prostate with 1mm accuracy. Both of these are published in high impact journals. Developed methods for imaging temperature changes in the prostate with high accuracy. In the third year, we applied the technique on patients in collaboration with investigators at NIH/NIC. We are seeking for a one-year No-Cost-Extension for completion of the last aim, i.e., precise RF ablation of the prostate.

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A. Introduction

The specific aims of the project were stated as follows in the original application:

We believe that the success of MR-guided therapy of the prostate depends on the improvement in signal-to-noise ratio. Currently, open MR magnets are used for MR-guided thermal therapy. Unfortunately, studies carried out in open magnets suffer from low SNR because of (a) low main magnetic field (it is known that field strength and SNR have a linear relation) and (b) the coils designed for the open magnets are not optimal because scanner manufacturers do not put enough effort into their development. We, therefore, plan to investigate the use of optimum RF coils in high-field short magnets for real-time monitoring of the RF ablation process. More specifically:

Aim 1. We will develop novel MRI probes for acquisition of ultra-high resolution images of the prostate.

Aim 1a. Based on the single-loop technology developed in our lab, we will design tiny and flexible endo-urethral probes with mechanical properties similar to Foley catheters. To obtain maximum performance, we will combine these probes with a homemade endo-rectal MRI probe and two homemade pelvic coils in a phased array combination.

Aim 1b. We will measure the performance of this design on a phantom and compare the results with the ultimate intrinsic SNR.

Aim 1c. We will test the performance and safety of the phased array coil for high-resolution imaging of the prostate on a dog model.

Aim 2. We will test the hypothesis that RF therapy of the prostate can be monitored using real-time MRI techniques on a dog model. For this purpose:

Aim 2a. We will construct an MR-compatible RFT needle in the form of an MRI antenna and connect it to the phased array coil developed in the previous aim to visualize the position of the needle and surrounding tissue during the ablation procedure.

Aim 2b. We will test the hypothesis that RF ablation of the prostate can be monitored in vivo on a dog model.

Aim 3. We will test the hypothesis that MR-guided RF ablation procedures can be carried out without a significant risk of morbidity and mortality on dogs. We plan to use histology as the gold standard for comparison, from which we will derive an effectiveness versus morbidity curve that could be used by clinicians to help determine the extent of ablation therapy.

Our overall aim is to develop an MR-guided prostate therapy system. After successful completion of this project, we will seek further funding to investigate the use of the developed system on human patients.

Although we had a significant progress during the past year, we were not able to complete the aims of the project, therefore we are seeking a no cost extension. First aim 1 of the project is completed. Second aim is almost complete. We started the third aim of the project. Our high pace in the project is partly related with the synergetic funds obtained from National Science Foundation, which enabled us to work closely with researchers at the Johns Hopkins Mechanical Engineering Department, Computer Science Department and also at NIH.

B. Body

B.1. *Coil Design.*

In this study, we designed a prostate phased array system that consisted of one 3-inch surface coil (General Electric), one endourethral coil, and two endorectal coils. Two types of endourethral coils were investigated: a loopless design that fit into a 2.5 mm diameter sheath; and a loop design that fit into a 5.3 mm diameter sheath. Two 1.3 x 2 cm rectal loop coils were mounted on the same probe, with the amount of overlap set so that interloop flux was minimized to ensure isolation. All coils were matched and decoupled by the appropriate circuitry. The safety analysis of this design has been completed and tested on animals.

B.2. *Accurate Needle Placement*

A micro coil tracking method has been developed to quickly (50 msec) and accurately (mean micro coil position error < 1 mm) locate the position and orientation of an intrarectal needle guide within the MR imaging volume. Via a mechanical positioning mechanism and extended control rods, the needle guide can be rotated and translated from outside of the closed scanner bore. Once the needle guide is positioned on the proper trajectory, the RF needle can be inserted to a controlled depth via an offset stop. The needle guide was situated inside a stationary rectal sheath that served to minimize prostate motion and also housed a local imaging coil.

We placed gold seeds in a dog prostate using this technique and measured the position of the seeds in order to test the accuracy of the needle positioning mechanism. We also injected blue dye and contrast agent mixture to the prostate with the purpose of developing an accurate prostate treatment technique. This method of MR-guided injection of therapeutic agents attracted attention in the research community.

B.3. *MR guided Biopsy*

We modified the above-mentioned system to enable MR-guided biopsy. We have tested this system on dog prostate. We later redesigned the system to make it suitable for the use in human prostate. He completed the safety testing. We established collaboration with investigators at NIH/NCI for testing this design. Our collaborators have obtained an IRB approval to test the design. We then applied the design on patients with known prostate cancer. In first set of patients, we placed gold markers in their prostate. In the second set of patients, we obtained biopsy and correlated the biopsy results with MRI findings.

We applied NIH for funding to continue research in this direction. As mentioned earlier, achievement of this complex task in a short time was possible because of the synergetic fund from National Science Foundation and collaboration from various researchers at NIH and JHU. We plan to continue collaboration with these researchers in order to keep the high pace of the research in the no-cost extension year of the project.

C. Key Research Accomplishments

We have completed the first aim of the project and are close to completion of the specific Aim 2 of the project. We took to liberty of changing the direction of the research project temporarily in order to utilize the great opportunity of applying the design to human patients, although it was not in our original aims. The experience that we obtained from these human studies will greatly enhance the quality of the results when we apply our well-developed technology to RF ablation of the prostate.

D. Reportable Outcomes

Our paper on the phased coil design to Magnetic Resonance in Medicine has been published, which concludes the specific aim 1 of the project. As a part of second aim, the mechanical design of the high-precision placement of the needles in the prostate is published in Radiology. In addition two these two peer reviewed journals, we have presented four abstracts in the conferences as given in the references.

E. Conclusions

We completed Aim 1 and most of Aim 2 of the study. We have published two peer reviewed journal articles. We plan to complete the second aim and the third aims of the project and publish our results in a peer-reviewed journal in the last year of the project.

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